CHEAT SHEETS HERO

PHYS. 131 Final

A comprehensive cheat sheet covering key concepts in fluid mechanics, oscillations, waves, sound, interference, and nuclear physics, designed for quick reference and effective problem-solving.

Fluids: Statics and Dynamics

Fluid Properties & Pressure

Density (ρ):
Mass per unit volume. $\rho = m/V$ (kg/m^3)

Pressure (P):
Force per unit area. $P = F/A$ (N/m^2 or Pa)

Hydrostatic Pressure:
Pressure at depth h in a fluid.
$P = h\rho g$, where g is the acceleration due to gravity (9.8 m/s^2)

Gauge Pressure:
Pressure relative to atmospheric pressure.
P_gauge = P_absolute - P_atm

Absolute Pressure:
Total pressure including atmospheric pressure.
P_absolute = P_gauge + P_atm

Atmospheric Pressure:
Standard atmospheric pressure.
1 atm = 101325 Pa

Pascal's Principle:
Pressure applied to an enclosed fluid is transmitted undiminished to every point in the fluid and the walls of the container.

Hydraulic Systems:
$F_1/A_1 = F_2/A_2$ (Force amplification)

Buoyant Force (F_b):
Upward force exerted by a fluid on an immersed object.
F_b = V_displaced * ρ_fluid * g

Archimedes' Principle:
The buoyant force on an object is equal to the weight of the fluid displaced by the object.

Apparent Weight:
Weight of an object in a fluid.
W_apparent = W_object - F_b

Manometer:
Measures pressure differences via column height difference.

Barometer:
Uses fluid column to measure atmospheric pressure.

Blood Pressure:
Measured in mmHg, systolic/diastolic readings.

Flow Rate (Q):
Volume of fluid passing a point per unit time.
$Q = V/t = Av$

Continuity Equation:
For incompressible fluids: $A_1v_1 = A_2v_2$

Streamlines:
Lines representing the path of fluid particles in a steady flow.

Viscosity (η):
A measure of a fluid's resistance to flow.

Fluid Dynamics

Bernoulli's Equation:
Relates pressure, velocity, and height in a flowing fluid.
$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$

Torricelli's Law:
Speed of fluid exiting an opening at depth h.
$v = \sqrt{2gh}$

Viscosity Formula:
$F = \eta * (VA/L)$, where F is the viscous force, A is the area, V is the velocity, and L is the distance between layers.

Poiseuille's Law:
$Q = [(P_2 - P_1)\pi r^4] / (8\eta L)$, where Q is the flow rate, r is the radius of the pipe, and L is the length of the pipe.

1/2ρv^2
(1/2mv)/v = KE/V

ρgh
mgh/V = PEg/V

Oscillations and SHM

Simple Harmonic Motion (SHM)

Definition: Periodic motion where the restoring force is proportional to the displacement. F = -kx	**Hooke's Law:** F = -kx (Restoring force of a spring)
Displacement (x): x(t) = A cos(ωt + φ), where A is amplitude, ω is angular frequency, and φ is phase constant.	**Angular Frequency (ω):** ω = √(k/m) = 2πf = 2π/T
Velocity (v): v(t) = -Aω sin(ωt + φ) V_max = Aω	**Acceleration (a):** a(t) = $-A\omega^2$ cos(ωt + φ) = $-\omega^2 x$ A_max = $A\omega^2$
Period (T): Time for one complete oscillation. T = 2π√(m/k)	**Frequency (f):** Number of oscillations per unit time. f = 1/T
Total Energy (E): E = KE + PE = $\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$	**Potential Energy (PE):** PE = $\frac{1}{2}kx^2$
Kinetic Energy (KE): KE = $\frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(A^2 - x^2)$	**SHM Graphs:** Displacement leads to velocity and acceleration graphs. Amax = -xmax
Vertical Spring Systems: Add mg to equilibrium; use same SHM formulas.	**Horizontal Spring Systems:** Normal SHM setup
L=L+L0 Change in L = x (displacement)= L+L0, so L = x - L0, h = L - sqrt(x^{2-L}2)	**U=elastic potential energy is same as PE** Gravitational force = mg

Pendulums & Damping

Simple Pendulum: T = 2π√(L/g), where L is length and g is gravitational acceleration.	**Restoring force:** F= mgθ = -mg/L*s
Damped Oscillations: Amplitude decreases over time due to energy loss.	**Damping Equation:** ma = -bv - kx, where b is the damping coefficient.
Underdamped: Oscillates with gradually decreasing amplitude.	**Overdamped:** Returns to equilibrium slowly without oscillating.
Critically Damped: Returns to equilibrium as quickly as possible without oscillating.	**Time Constant (τ):** τ = m/b (Time for amplitude to decrease by a factor of e)
Energy Loss: Damped oscillator loses energy twice as fast as amplitude.	**Total energy of a damped oscillator:** E(t)=1/2kA(t)^2
h equation: h = L -sqrt($L^{2 - x}$2)	**Resonance:** Max amplitude when driven frequency ≈ natural frequency.
K = w^2 * m = sqrt(g/L)^2 * m = g/L * m = mg/L Shown below as: K = mg/L T = 2pi*sqrt (m/k) = 2pi*sqrt (m/(mg/L))	**A(t)=A0e^(-bt)**
Damped equation of motion: x(t)+bv(t)+kx(t)=0	**Conservation of energy:** Convert potential energy equation 1/2kx^2 to gravitational potential energy mgh. So you get mgh = 1/2mv2 since you cannot get k constant from simple pendulum.

Traveling and Standing Waves

Traveling Waves

Transverse Wave: Oscillation is perpendicular to the direction of wave travel.	**Longitudinal Wave:** Oscillation is parallel to the direction of wave travel.
Wave Speed (v): v = λf, where λ is wavelength and f is frequency.	**Wave Function:** D(x, t) = A sin(kx - ωt + φ), where A is amplitude, k is wave number, ω is angular frequency, and φ is phase constant.
Wave Number (k): k = 2π/λ	**Angular Frequency (ω):** ω = 2πf
Phase Constant (φ): Initial phase offset.	**Phase Difference:** Δx/λ × 2π
Snapshot Graph: D vs. x at a specific time.	**History Graph:** D vs. t at a specific location.
u (linear tension) m/L or density * area	**Tension, T = mg** (mass times gravity)
v=sqrt(T/u) u in v = sqrt(T/u) is the linear mass density (kg/m), and T is the tension	**Direction of transverse wave depends on sign of wt in D(x, t).** +ive is left since this is a sin wave.

Standing Waves

Definition: Superposition of two waves traveling in opposite directions, creating fixed nodes and antinodes.	**Nodes:** Points of zero displacement.
Antinodes: Points of maximum displacement.	**Fixed Ends (Strings):** Nodes at both ends.
Open Ends (Pipes): Antinodes at open ends.	**Fundamental Frequency (f_1):** Lowest frequency of a standing wave.
Harmonics (f□): Integer multiples of the fundamental frequency. f□ = nf_1	**Overtones:** Frequencies above the fundamental frequency.
Wavelength in terms of length λ = 2L/n	**Closed-closed:** add info
Open-closed: add info	**Open-open:** add info
Assume frequency an instrument needs to produce is the fundamental.	**Fundamental freq: f1=v/λ = v/2L** All other freq.: v/λ = v/L = 2f1

Sound, Interference, and Nuclear Physics

Sound and Interference

Sound Intensity (I): Power per unit area. $I = P/A$ (W/m^2)	**Sound Level (β):** Measured in decibels (dB). $\beta = 10 \log_{10}(I/I_0)$, where $I_0 = 10^{-12}$ W/m^2
Doppler Effect: Change in frequency due to relative motion between source and observer.	**Observer Moving:** f_o = f_s(v ± v_o)/v, where v is the speed of sound and v_o is the observer's speed.
Source Moving: f_o = f_s*v/(v ± v_s), where v_s is the source's speed.	**Constructive Interference:** Path difference = nλ (n = 0, 1, 2, ...)
Destructive Interference: Path difference = (n + ½)λ (n = 0, 1, 2, ...)	**Beats:** Periodic variations in amplitude due to interference of two slightly different frequencies.
Beat Frequency: f_beat = $\lvert f_1 - f_2 \rvert$	**Speed of light in media** v=c/n
Bright fringe: ym (displacement) = (m*wavelength*Length)/d, where, d = distance between slits, L = distance between slits and screen	**Constructive:** **delta(L)=n*wavelength**
**Destructive: delta(L) = (n +1/2)wavelength*	**Mach number:** speed of source/speed of sound

Nuclear Physics

Atomic Number (Z): Number of protons in the nucleus.	**Mass Number (A):** Number of protons and neutrons in the nucleus.
Binding Energy (BE): Energy required to separate a nucleus into its constituent nucleons.	**BE = (Zm_p + Nm_n - m_nucleus)c²** Where m_p is proton mass, m_n is neutron mass, and m_nucleus is the nucleus mass.
Radioactive Decay: Spontaneous emission of particles or energy from an unstable nucleus.	**Decay Constant (λ):** Probability of decay per unit time.
Half-Life ($T_1/_2$): Time for half of the radioactive nuclei to decay. $T_1/_2 = \ln(2)/\lambda$	**Activity (A):** Rate of decay. $A = \lambda N(t)$
Decay Law: $N(t) = N_0e$^(-λt), where N_0 is the initial number of nuclei.	**Radiation Types:** α (alpha), β (beta), γ (gamma)
Radiation Dose: Energy absorbed per unit mass.	**Dose Equivalent:** Takes into account the biological effect of different types of radiation.
N(t),A(t), lambda	**Energy from decay**